5.16.22 MAKING AND CURING COMPRESSION AND FLEXURAL TEST SPECIMEN IN THE FIELD (Kansas Test Method KT-22)

a. SCOPE

This method covers procedures for making and curing test specimens in the field, using freshly mixed concrete produced for construction or maintenance work. KT-22 reflects testing procedures found in AASHTO T 23.

b. REFERENCED DOCUMENTS

b.1. KT-17; Sampling Fresh Concrete

b.2. KT-18; Air Content of Freshly Mixed Concrete By the Pressure Method

b.3. KT-19; Air Content of Fresh Concrete By the Volumetric Method

b.4. KT-20; Weight Per Cubic Meter (Foot), Yield Cement Factor and Air Content (Gravimetric) of Fresh Concrete

b.5. KT-21; Slump of Portland Cement Concrete

b.6. AASHTO T 23; Making and Curing Concrete Test Specimens in the Field

c. APPARATUS

c.1. Compressive strength specimens shall be cylinders of concrete cast and hardened in an upright position. The standard specimen shall be the 150 by 300 mm (6 by 12 in) cylinder when the maximum size of the coarse aggregate does not exceed 50 mm (2 in). When the nominal maximum size of the coarse aggregate does not exceed 25 mm (1 in) the specimens may be 100 by 200 mm (4 by 8 in) cylinders. All molds are sampled prior to issuance to field offices and tested in the Materials and Research Center for conformance with specifications. No cylinder molds should be used until they have been tested and accepted. Individual molds that deviate from dimensional or other requirements or have been damaged should be discarded. All plastic molds are to be provided with plastic lids.

c.2. Beam molds shall be rectangular in shape and of the dimensions required to produce test specimens that are nominally 150 by 150 mm (6 by 6 in) with a minimum length of 530 mm (21 in). The inside surfaces of the molds shall be smooth. The sides, bottom, and ends shall be at right angles to each other and shall be straight and true and free of warpage. Maximum variation from

the nominal cross section shall not exceed 3.2 mm (1/8 in) for molds with depth or breadth of 152 mm (6in) or more. Molds shall produce specimens not more than 1.6 mm (1/16 in) shorter than the required length of 530 mm (21 in), but may exceed it by more than that amount. They should be checked for configuration and fit prior to each use to ensure that there will not be a leakage and that the test specimen will be molded to specified dimensions.

c.3. Tamping Rods--Two sizes are specified. Each shall be a round, straight steel rod with at least the tamping end rounded to a hemispherical tip of the same diameter as the rod. Both ends may be rounded if preferred.

c.3.a. Large Rod: 16 mm (5/8 in) in diameter and approximately 610 mm (24 in) long.

c.3.b. Small Rod: 10 mm (3/8 in) in diameter and approximately 305 mm (12 in) long.

c.4. Vibrators.

c.4.a. Internal vibrators may have rigid or flexible shafts, preferably powered by an electric motor. The diameter of the vibrating element shall not be less than 19 mm (0.75 in) or more than 38 mm (1.50 in) and the length of the shaft should be 600 mm (24 in) or more. The frequency shall be 7,000 vpm or greater during usage.

c.4.b. External vibrators may be either a table type or a plank[a] type, with provision for securely clamping the mold to the apparatus. The frequency shall be 3,600 vpm or higher during usage.

A vibrating reed tachometer should be used to check the frequency of vibration of each type.

NOTE a: Vibratory impulses are frequently imparted to plank vibrators through electromagnetic means or by use of an eccentric weight on the shaft of an electric motor, or on a separate shaft driven by a motor.

c.5. Small tools and other items such as shovels, pails, trowels, wood float, blunted trowels, straightedge, feeler gage, scoops, rules and a wheelbarrow or cart for transporting the fresh concrete to the place where test specimens will be molded.

c.6. Slump apparatus as specified in KT-21.

c.7. Sampling and mix apparatus as specified in KT-17.

c.8. Air content apparatus as specified in KT-18, KT-19 or KT-20.

d. TEST PROCEDURE

d.1. Obtain a sample of concrete in accordance with KT-17. Note and record the place where the batch of concrete represented by the sample was deposited.

d.2. Measure and record the slump of the concrete in accordance with KT-21. The concrete used for the test may be returned to the forms or discarded.

d.3. Determine the air content, when required, in accordance with KT-18, KT-19 or KT-20 and record. Concrete used in performing the air content test shall not be used in fabricating test specimens.

d.4. Determine and record the temperature of the concrete as specified in KT-17 **f**.

d.5. Molding Specimens: The following procedures are applicable to both compression and flexure specimens.
d.5.a. Mold specimens promptly on a level, rigid, horizontal surface, free from vibration and other disturbances, at a place as near as practicable to the location where they are to be stored.

d.5.b. Placing the concrete: Place the concrete in the molds using a scoop, blunted trowel, or shovel. Select each scoopful trowelful, or shovelful of concrete from the mixing pan to ensure that it is representative of the batch. Remix the concrete in the mixing pan with a shovel or trowel to prevent segregation during the molding of the specimens. Move the scoop, shovel, or trowel around the perimeter of the mold opening when adding concrete to ensure an even distribution of the concrete and to minimize segregation. Further distribute the concrete by use of a tamping rod prior to the start of consolidation. In placing the final layer, the operator shall attempt to add an amount of concrete that will exactly fill the mold after compaction. Do not add nonrepresentative concrete to an underfilled mold.

d.5.c. Number of layers: Make specimens in layers as indicated in Table 1.

d.6. Consolidation:

d.6.a. Methods of consolidation: Preparation of satisfactory specimens requires different methods of consolidation. The methods of consolidation are rodding, and internal or external vibration. Base the selection of the method of consolidation on the slump, unless the method is stated in the specifications under which the work is being performed. Rod concrete's with a slump greater than 75 mm (3 in). Rod or vibrate concrete's with slump of 25 to 75 mm (1 to 3 in). Vibrate concrete's with slump of less than 25 mm (1 in). Concrete's of such low water content that they cannot be properly consolidated by the methods described herein, or requiring other sizes and shapes of specimens to represent the product or structure, are not covered be this method. Specimens for such concretes shall be made in accordance with the requirements of AASHTO T-126 with regard to specimen size and shape and method of consolidation.

d.6.b. Rodding: Place the concrete in the mold, in the required number of layers of approximately equal volume. For cylinders, rod each layer with the rounded end of the rod using the number of strokes specified in Table 2. The number of roddings per layer required for beams is one for each 1250 mm^2 (2 in^2) top surface area of the specimen. Rod the bottom layer throughout its depth. Distribute the strokes uniformly over the cross section of the mold and for each upper layer allow the rod to penetrate about 12 mm (½ in) into the underlying layer when the depth of the layer is less than 100 mm (4 in), and about 25 mm (1 in) when the depth is 100 mm (4 in) or more. After each layer is rodded, tap the outsides of the mold lightly 10 to 15 times with the mallet, to close any holes left by rodding and to release any large air bubbles that may have been trapped. Use an open hand to tap light-gage single-use molds which are susceptible to damage if tapped with a mallet. After tapping, spade the concrete along the sides and ends of beam molds with a trowel or other suitable tool.

d.6.c Vibration: Maintain a uniform time period for duration of vibration for the particular kind of concrete, vibrator, and specimen mold involved. The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator. Usually, sufficient vibration has been applied as soon as the surface of the concrete has become relatively smooth. Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation. Fill the molds and vibrate in the required number of approximately equal layers. Place all the concrete for each layer in the mold before starting vibration of that layer. When placing the final layer, avoid overfilling by more than 6 mm (¼ in). Finish the surface either during or after vibration where external vibration is used. Finish the surface after vibration when internal vibration is used. When the finish is applied after vibration, add only enough concrete with a trowel to overfill the mold about 3 mm (1/8 in). Work it into the surface and strike it off.

d.6.d. Internal vibration: The diameter of the vibrating element, or thickness of a square vibrating element, shall be in accordance with the requirements of **c.4.** For beams, the vibrating element shall not exceed one-third of the width of the mold. For cylinders, the ratio of the diameter of the cylinder to the diameter of the vibrating element shall be 4.0 or higher. In compacting the specimen, the vibrator shall not be allowed to rest on the bottom or sides of the mold. Carefully withdraw the vibrator in such a manner that no air pockets are left in the specimen.

d.6.e. Cylinders: Use three insertions of the vibrator at different points for each layer. Allow the vibration to penetrate through the layer being vibrated, and into the layer below, approximately 25 mm (1 in). After each layer is vibrated, tap the outsides of the mold lightly 10 to 15 times with the mallet, to close any holes left by vibrating and to release any large air bubbles that may have been trapped. Use an open hand to tap light-gage single-use molds which are susceptible to damage if tapped with a mallet.

d.6.f. Beam: Insert the vibrator at intervals not exceeding 150 mm (6 in) along the centerline of the long dimension of the specimen. For specimens wider than 150 mm, use alternating insertions along two lines. Allow the shaft of the vibrator to penetrate into the bottom layer approximately 25

mm (1 in). After each layer is vibrated, tap the outside of the mold lightly 10 to 15 times with the mallet, to close any holes left by vibrating and to release any large air bubbles that may have been trapped.

d.6.g. External vibration: When external vibration is used, take care to ensure that the mold is rigidly attached to or securely held against the vibrating element or vibrating surface.

d.7. Finishing: After consolidation, unless the finishing has been performed during the vibration, strike off the surface of the concrete and float or trowel as required. Perform all finishing with the minimum manipulation necessary to produce a flat even surface that is level with the rim or edge of the mold and that has no depressions or projections larger than 3.2 mm (1/8 in).

d.7.a. Cylinders: After consolidation, finish the top surfaces by striking them off with the tamping rod where the consistency of the concrete permits or with a wood float or trowel. If desired, cap the top surface with a thin layer of stiff Portland cement paste which is permitted to harden and cure with the specimen. If using plastic molds and lids, cap the cylinder with the supplied lid immediately after finishing.

d.7.b. Beams: After consolidation of the concrete, strike off the top surface to the required tolerance to produce a flat even surface. A wood float may be used.

d.8. Initial storage: Immediately after being struck off, the specimens shall be moved to the storage place where they will remain undisturbed for the initial curing period. If specimens made in single-use mold are moved, lift and support the specimens from the bottom of the molds with a large trowel or similar device.

e. CURING SPECIMENS

e.1. Immediately after finishing, precautions shall be taken to prevent evaporation and loss of water from the specimens. Protect the outside surfaces of cardboard molds from contact with wet burlap or other sources of water. Cardboard molds may expand and damage specimens at an early age if the outside of the mold absorbs water. Cover specimens with a nonabsorbent, nonreactive plate or sheet of impervious plastic. Wet burlap may be used over the plate or plastic sheet to help retard evaporation, but the burlap must not be in contact with the surface of the concrete.

e.2. Initial Curing: After molding, the specimens shall be stored in a temperature range between 16 to 27^{o}C (60 to 80^{o}F), and in a moist environment preventing any loss of moisture up to 48 hours[b]. At all times the temperature in and between specimens shall be controlled by shielding from direct rays of the sun and radiant heating devices. Specimens that are to be transported to the laboratory for standard curing (See **e.3.**) before 48 hours shall remain in the molds in a moist environment, until they are received in the laboratory, demolded and placed in standard curing. If

specimens are not transported within 48 hours, the mold shall be removed within 24 ± 8 hours and standard curing used until transported. (See **f.**)

e.2.a. Under no circumstances should the lid be removed from plastic molds, until the mold is stripped from the cylinder.

NOTE b: It may be necessary to create an environment during initial curing to provide satisfactory moisture and to control the temperature. The specimens may be immersed immediately in saturated limewater, and/or stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap, or in heavyweight closed plastic bags. Immersing in saturated limewater is not acceptable for specimens in cardboard or other molds that expand when immersed in water. Other suitable methods may be used provided the foregoing requirements limiting specimen temperature and moisture loss are met. The temperature may be controlled by ventilation, or thermostatically controlled cooling devices, or by heating devices such as stoves, light bulbs, or thermostatically controlled heating elements. Temperature record of the specimens may be established by means of maximum-minimum thermometers. Early age results may be lower when stored near 16°C (60°F) and higher when stored near 27°C (80°F).

e.3. Standard Curing

e.3.a. Cylinders: Upon completion of initial curing and within 30 minutes after removing the molds, store specimens in a moist condition with free water maintained on their surfaces at all times at a temperature of 23 ± 1.7°C (73.4 ± 3°F). Temperatures between 20 and 30°C (68 and 86°F) are permitted for a period not to exceed 3 hours immediately prior to test if free moisture is maintained on the surfaces of the specimen at all times, except when capping with sulfur mortar capping compound. When capping with this material, the ends of the cylinder will be dried. Specimens shall not be exposed to dripping or running water. The required moist storage can be obtained by immersion in saturated limewater or by storage in a moist room or cabinet meeting the requirements of AASHTO M 201.

e.3.b. Beams: Beams are to be cured the same as cylinders, as stated in **e.3.a.,** except for a minimum of 20 hours prior to testing, they shall be stored in saturated limewater at 23 ± 1.7°C (73.4 ± 3°F). Drying of the surfaces of the beam shall be prevented between removal from limewater and completion of testing[c].

NOTE c: Relatively small amounts of surface drying of flexural specimens induce tensile stresses in the extreme fibers that will markedly reduce the indicated flexural strength.

e.4. Curing at Remote Sites:

e.4.a. Specimens prepared and stored at remote sites which do not have facilities for controlling temperature within the tolerance 23 ± 1.7°C (73.4 ± 3°F) shall be cured in accordance with the provisions of **e.3.** except as modified by **e.4.**

e.4.b. Initial curing at remote sites shall be in accordance with **e.2.**

e.4.b.1. Specimens not to be transported or to be transported after 48 hours age may be cured without demolding provided that loss of moisture is prevented in accordance with **e.2.** until the time of transportation or testing.

e.4.c. Standard curing at remote sites: Specimens to be stored at a remote site and shipped to a laboratory for test or to be tested at the remote site shall be cured in accordance with **e.4.a., e.4.b.,** and **e.4.b.1.** until the time of shipment or test. Specimens shall not be exposed to dripping or running water.

e.4.c.1. Beam specimens to be stored and tested at remote sites shall be cured in accordance with **e.4.,** except that for a minimum of 20 hours prior to testing, they shall be stored in saturated limewater at 16 to 27°C (60 to 80°F). Drying of the surfaces of the beam shall be prevented between removal from the limewater and completion of testing[d].

NOTE d: Curing of specimens at remote sites in accordance with **e.4.** may yield significantly different results as compared to specimens cured in accordance with **e.2.**

e.5. Curing for Determining Form Removal Time or When a Structure May be Put into Service:

e.5.a. Cylinders: Store cylinders in or on the structure as near to the point of deposit of the concrete represented as possible. Protect all surfaces of the cylinders from the elements in as near as possible the same way as the formed work. Provide the cylinders with the same temperature and moisture environment as the structural work. Test the specimens in the moisture condition resulting from the specified curing treatment. To meet these conditions, specimens made for the purpose of determining when a structure may be put in service shall be removed from the molds at the time of removal of formwork.

e.5.b. Beams: As nearly as practicable, cure beams in the same manner as the concrete in the structure. At the end of 48 ± 4 hours after molding, take the molded specimens to the storage location and remove from the molds. Store specimens representing pavements or slabs on grade by placing them on the ground as molded, with their top surfaces up. Bank the sides and ends of the specimens with earth or sand that shall be kept damp, leaving the top surfaces exposed to the specified curing treatment. Store specimens representing structure concrete as near to the point in the structure they represent as possible and afford them the same temperature protection and moisture environment as the structure. At the end of the curing period leave the specimens in place exposed to the weather in the same manner as the structure. Remove all beam specimens from field storage and store in lime water at 23 ± 2.8°C (73.4 ± 5°F) for 24 ± 4 hours immediately before time of testing to ensure uniform moisture condition from specimen to specimen. Observe the precautions given in **e.3.b.** to guard against drying between time of removal from curing to testing.

f. SHIPPING SPECIMENS

f.1. NON-QC/QA

Ship all concrete cylinders to the Materials and Research Center for testing. Suitable shipping containers are available through the District Materials Engineer. Care should be taken to insure concrete cylinders do not freeze during shipment.

Properly identify each cylinder and encase in a plastic bag or pack in damp sawdust. Schedule the shipment so that the cylinders will arrive in the laboratory approximately one week before they are to be tested so that they can be capped and conditioned prior to testing.

Attach a copy of KDOT Form 610, properly filled out, or a CMS identification number to each shipping container and forward copies to the Engineer of Tests by mail. The Field Engineer should not sign the form in the lower right corner as it is to be signed by the Engineer of Tests.

If the cylinders are to be tested at any age other than 28 days, the desired age of test should be noted on the form.

Concrete beams are tested at the project or District Laboratory.

Table 1 Number of layers Required For Specimens

Specimen Type and Size as Total Depth mm (in)	Mode of Compaction	Number of Layers or Depth in mm (in) of Layers
Cylinders:		
300 (12) or less	rodding	3 equal layers
Over 300 (12)	rodding	100 (4) depth as near as practicable
Over 300 (12) to 460 (18)	vibration	2 equal layers
Over 460 (18)	vibration	200 (8) depth as near as practicable
Beam:		
150 (6) to 200 (8)	rodding	2 equal layers
Over 200 (8)	rodding	100 (4) depth as near as practicable
150 (6) to 200 (8)	vibration	1 full depth layer
Over 200 (8)	vibration	200 (8) depth as near as practicable

TABLE 2 Diameter of Rod and Number of Roddings to be Used in Molding Cylinder Test Specimens

Diameter of Cylinder, mm (in)	Diameter of Rod, mm (in)	Number of Strokes/ Layer
100 (4)	10 (3/8)	25
152 (6)	16 (5/8)	25
200 (8)	16 (5/8)	50
250 (10)	16 (5/8)	75